Task Modeling for Collaborative Authoring

Gerrit v.d.Veer
Open Universiteit
Heerlen
The Netherlands
gvv@ou.nl

Olga Kulyk
Topicus
Deventer
The Netherlands
Olga.kulyk@
topicus.nl

Dhaval Vyas
UTwente
Enschede
The Netherlands
d.m.vyas@
utwente.nl

Onno Kubbe
Ministry of
Finance
The Netherlands
o.kubbe@
belastingdienst.nl

Achim Ebert
U.Kaiserslautern
Germany
ebert@
cs.uni-kl.de

ABSTRACT

Motivation –Task analysis for designing modern collaborative work needs a more fine grained approach. Especially in a complex task domain, like collaborative scientific authoring, when there is a single overall goal that can only be accomplished only by collaboration between multiple roles, each requiring its own expertise. We analyzed and re-considered roles, activities, and objects for design for complex collaboration contexts. Our main focus is on a generic approach to design for multiple roles and subtasks in a domain with a shared overall goal, which requires a detailed approach. Collaborative authoring is our current example.

This research is incremental: an existing task analysis approach (GTA) is reconsidered by applying it to a case of complex collaboration. Our analysis shows that designing for collaboration indeed requires a refined approach to task modeling: GTA, in future, will need to consider tasks at the lowest level that can be delegated or mandates. These tasks need to be analyzed and redesigned in more in detail, along with the relevant task object.

Keywords

Task analysis, roles and activities, collaborative authoring

INTRODUCTION

Task domains change due to the availability of information and communication technology (ICT). Collaboration between people (and other agents) changes due to the same cause. The general picture is that roles get exchanged more easily between actors, and that activities get more easily delegated to systems. In addition, it seems that mandating of roles, and delegation of activities, occurs at a more detailed level than before. Our analysis techniques need to be reconsidered in order to set more precise design requirements for supporting technology.

In this paper we explore the need for a more fine-grained task analysis and task modeling approach. We have chosen the domain of academic collaborative authoring, since this domain will be well known by our audience. By systematically applying, and at the same time refining, the GTA (Groupware Task Analysis, van Welie and van der Veer, 2003) approach, we will show the benefits of a more fine grained approach.

In the next section we will sketch our task analysis approach. In the section on the example domain we provide an introduction to the task domain of collaborative authoring, and the subsequent section provides an impression of state of the art ICT support in this domain, while the section on collaborative authoring in the domain of knowledge work provides an account of our empirical investigations. Finally we provide our conclusions and reflections.

TASK ANALYSIS REFINED

Our design approach is based on GTA, a method that starts with an analysis and modeling of the existing task world. Subsequently, GTA envisions and models the future task world for the same domain where expected new ICT support will be available and in actual use. In this paper we only consider the first phase.

Like many task analysis methods (Mistrzyk, 2009; Asimakopoulos et al., 2011) GTA originally aimed at a hierarchical task model for design of ICT support. In some domains, however, multiple experts are collaborating in a way that requires (or enables) them to share high level goals, though, at the same time, split the work, interrupt, work at different locations and times, and use technology for supporting a large variety of activities, both individually and joined. The actual structure of the complexity of the activities is mainly left to the creativity and availability of the various experts, and it makes sense to focus the design no longer on the complex task structure (even if these might still be modeled in a hierarchical way) but on supporting a multitude of rather basic but very essential activities in order to support the process, where the human experts are completely in control. This requires us to reconsider the relevance of the different task analysis concepts, as well as the kind of detail needed for the design of support.

As in any other domain, task analysis for the domain of scientific paper writing process concerns five major conceptual entities (this is in fact equivalent to the ontology of any task analysis method): activities (previously mostly labeled “tasks”); agents; roles; situation and objects; events.

Activities. Tasks may be defined as activities for which an agent has a goal. Tasks can be distinguished at many levels, from high level tasks (e.g., “write a book chapter”) to low level (e.g., “insert the correct publication year for the first journal paper by Moran on Command Language Grammars"). Activities in all accounts concern objects: (a) either in the conditions allowing or enforcing the start or the end of an activity (*if the attribute value "publication year" of the object "reference to Moran on CLG" has been found, then* ....); or (b) as subject to the performance of a task (*do format the list of references*). Tasks can be performed by a single agent or split in subtasks that may be performed by different agents. We label any (sub) task an activity if it may be normally delegated or mandated by one agent to another (e.g., an author might delegate spell checking to a human colleague, or delegate it to Microsoft Word). These types of sub tasks will often feature in our attempts to support work by redesigning the future task world, and, hence, activities are the units of task that are most relevant in envisioning change in future task worlds. We make a distinction between mandate, where decisions on details of the activity and of choices are left to the agent mandated to, and delegation, where decisions are already taken (in many cases implicitly or by default).

Agents. In modeling an existing task world, agents are the instances that perform all or some (sub) tasks. In general several types of agents can be distinguished, mostly: (a) different types of humans, characterized by distinct features like level of expertise and specializations in the task domain (students, secretaries, laboratory staff, etc.); (b) groups of people and institutes (e.g., the secretariat, the faculty); and (c) machines (Microsoft Word, the voice mail system).

Roles. Subtasks are often delegated or mandated. A coherent package of subtasks (an *activity*) that may be delegated or mandated is referred to as a role. In order to assign a role to some agent, the characteristics of the *agent* should match the required expertise and specializations.

Situation and Objects. The situation is the physical and conceptual territory where relevant objects are, where agents perform their roles, and where activities take place. An *activity* mostly changes an object: either by changing values of its attributes, or by creating or destroying the object. In addition, objects may feature in start- or stop-conditions of tasks (activities). Modeling objects makes sense only if objects can, or will, be shared between agents as a result of activity delegation. Consequently objects are related to roles in the sense of rights that an agent playing a certain role has towards the object: e.g. in some role, the agent may have the right to inspect certain attribute values of the object (like the date of creation); or have the right to change attribute values; to change the content (add or delete certain other objects contained in the object concerned); to keep a copy of the object; and / or to delete the object, etc. Representations (of objects, activities, agents, roles, delegation, etc.) often derive their meaning from the situation where these are communicated and understood: in court in certain countries, taking the role of judge is indicated by wearing a wig; in hospitals, the role of physician is indicated by having a stethoscope around one's neck.

Events. Events are only modeled separately as far as they concern relevant changes in the state of (situation and objects in) the task world that are not the result of task performance or task delegation in the domain. E.g., in modeling collaborative authoring the arrival of a requested reference should be modeled as the result of a task delegation. The unpredicted shut down of a file server containing a database of references should be modeled as an event.

For understanding a current task domain, we need to collect knowledge on all five entities, to model this, and to analyze it. Below we will discuss the task knowledge sources and the major techniques for eliciting the relevant knowledge and how to model this knowledge.

For envisioning a future task world, we need to consider how to re-allocate activities to other agents (including machines); what objects are needed especially for delegation of activities to machines; how to represent these objects; and what kind of interaction paradigms to provide for human users of the machines. In domains where multiple human agents (possibly of different agent types and in different roles) are expected to collaborate through, and with, machines we need to consider, in addition, how collaboration may be supported may be supported by providing interaction with (often several different) types of representations. This part of task analysis will not be covered in the current paper.

Task Knowledge Sources

In task analysis (according to GTA as well as in most state of the art task analysis approaches) there are different sources of knowledge.

Some relevant knowledge is individual knowledge, residing (at least) with the agents that regularly perform certain activities (we label these agents "experts" in the task domain). Experts know (because they learned) and often they are able to speak about it. In some cases, however, they show the ability but they are not fully aware. E.g., most people, especially children, are able to speak their native language without being aware of the complex of grammar rules they are applying. Only their (speaking or writing) behavior shows their knowledge. Individual knowledge, thus, is sometimes explicitly and sometimes implicitly available.

Some relevant knowledge is mainly available in the group that is working in the situation of a task world. People behave (more or less) according to explicit laws and rules that are well documented but that nobody (except, e.g., some specialist lawyers) will be able to produce without the documents at hand. These documents and artifacts are a main source for collecting explicit group knowledge. On the other hand, natural groups in a task situation ("communities of practice" in the ethnographic sense, Jordan, 1996) develop ways to work and interact in their context. In many cases (most) people in a community of practice are not fully aware of the specifics of how they work together, though they show they are well able to understand each other's signs and to adequately react to these. We will systematically discuss knowledge sources.

Collecting and Analyzing Explicit Expert Knowledge

Expert knowledge is readily available. One may ask the experts, i.e., some of the various types of agents that actually are used to play roles in the task domain. Interviewing is the most obvious start, and interview techniques have been developed that carefully aim at unbiased knowledge elicitation (Sebillotte, 1988).

Collecting and Analyzing Implicit Expert Knowledge

If experts cannot readily speak about, the best way to reach understanding is record them performing relevant tasks. After the recording, questions triggered by unexpected or not fully understood behavior might well result in additional explicit knowledge. If the answers do not bring complete understanding, hermeneutic techniques (van der Veer and Puerta Melguizo, 2003) will have to be used, which requires specialized training. We do not elaborate details of this in the current paper. One relevant aspect of knowledge we collected in the current project concerns a detailed list of physical objects and their spatial configuration as they feature in experts' work places and as they, either, trigger, or support, expert behavior in the task domain we investigated. The actual technique here consisted of taking pictures and video clips of offices as actually occupied by experts and asking the experts to explain the why and how of interacting with their physical world.

Collecting and Analyzing Explicit Group Knowledge

In any task domain there exist documents and other artifacts that reflect common knowledge. Part of this knowledge is specific for a certain community of practice (house rules for a certain group or for an institute), part is more generic. Relevant for the design of future supporting technology, is knowledge pointing to individual solutions or design ideas that might be considered for generic adoption. In the domain we are investigating there are some studies available that provide us with this type of knowledge (Mandviwalla, 1995; Sellen and Harper, 2003; Forte, 2007).

Collecting and Analyzing Implicit Group Knowledge

Jordan and Henderson (1995) provide a detailed account of techniques in the methodology of ethnography that allow us to collect and analyze interactive behavior in communities of practice. However, most ethnographic techniques are very time consuming and require extended training. One may choose to apply rather simple and economic techniques like contextual interviews, diary keeping (a type of ethnography by proxy), and job shadowing.

THE EXAMPLE DOMAIN: COLLECTIVE AUTHORING

For ages human beings have been writing text, and for centuries scientists have been publishing for their peers and students. Science became complex and scientific work increased to require more and more different disciplines, skills, and specialist knowledge. At the same time (roughly speaking) new techniques became available to support collaboration in this domain: the printing press, faxes, word processors, CSCW support (computer supported collaborative work), large screens, and 3D representation. While both the needs from the domain of paper writing, and the opportunities of new technology, seem to trigger as well as to follow each other, the current situation is not without challenges. Based on our own experiences as well as on the literature we list some evident problems:

- People have to combine working on physical documents and working on electronic documents, which includes using various incompatible interaction techniques, like writing with pencil and eraser; desk top interaction; or searching, storing, and manipulating in a 3D world.
- People have to manage a growing amount of available document collections, and to oversee increasingly complex networks of (re)sources.
- Knowledge work is teamwork that tends to spread out to different locations, asynchronous working times, and a diversity of preferred representations.
- Knowledge work is long-time work and gets interrupted.
- In their daily work with documents, humans often have to undertake mindless and repetitive workflows. One such common, menial task is searching in a document or a whole stack of documents to find a concrete text passage.
- Still, humans have limited capacity for attention and working memory.
- Physical and virtual desktops have limited real estate.

At the same time, ICT provides the current knowledge worker with rather advanced opportunities:

- Databases and data structures, electronic archives, and advanced annotation and search techniques.
- The ever increasing world wide web, making sources available and providing retrieval opportunities.
- Advanced techniques for searching large databases and transferring data into knowledge.
- Advanced representation techniques, both in the sense of new hardware (screen size, screen resolution, and 3D display techniques), and paradigms and software to represent (Card et al., 1999; Ware, 2000; Spence, 2007).

- New interaction modalities like speech, (3D) object manipulation, gestures (Rico and Brewster, 2010), haptic/tactile input/output (Lawrence et al, 2004).

- Powerful PCs and graphics hardware has made its way from the multimedia labs to the homes of users (games are a driving force here).

- Advanced ways of collaboration through the internet, including high bandwidth as well as optimized compression to accommodate high speed transmission of shared visual data.

In our example we focus on collaborative authoring in scientific communities with state of the art ICT support. Our ultimate objective is to develop a fundamental insight in order to envision the future task world of collaborative scientific authoring from the viewpoint of the different participants (users of state of the art ICT), and to identify the needs and requirements for future user support in a 'document world'.

STATE OF THE ART DOCUMENT INFORMATION ENVIRONMENT

Usually, people are operating their computers by means of a graphical user interface. The 2D WIMP paradigm has been extended towards three-dimensional user interfaces (3DUIs) in the past years. One example is Robertson's Data Mountain (Robertson et al., 1998) which tries to leverage natural human capabilities, particularly cognitive and perceptual skills. Results show that users are able to exploit spatial abilities and to transfer organizational knowledge to a 3D virtual environment (VE). However, users complained that navigation controls were "...confusable or not grouped properly by function".
Cockburn and McKinsey (2002) compared the effect of 2D and 3D interfaces, tightly resembling Data Mountain. They report that subjects' ability to relocate web pages deteriorated as their freedom to use a third dimension increases in both virtual and physical environments. The overall user satisfaction was negatively assessed as users found the 3D interface less efficient and more cluttered. Cockburn (2004) found that spatial memory is fairly unaffected by the presence or absence of 3D interfaces in regular monocular static displays. It remains unclear, whether a "perfect" virtual 3D implementation would produce spatial memory advantages or disadvantages.

Going along with this general research, several prototypes for a new generation of desktops have been researched and developed. As examples we have chosen three approaches, which give different insights in how the future desktop scenario may look like. Card et al. have developed the 3Book (2004-a; 2004-b; Hong et al., 2006), a prototype of a scalable 3D virtual book. With this approach it is possible to represent and interact with large, full-sized virtual books. The authors used a multi-resolution strategy for texturing, allowing its manipulation at an interactive speed.

The reader of the 3Book is able to bookmark locations, to compare multiple locations, to copy parts into a text editor, to highlight parts, to slide-out pages, and to browse through it with support of smart indexes. Figure 1 shows the 3Book representation of the book "Readings in Information Visualization: Using Vision to think", which has a large number of pages and a large page format.

Figure 1. 3Book representation of "Readings in Information Visualization" (Card et al., 3004-a)

BumpTop (Agarawala et al., 2006) is a 2D environment in which wafer-like icons representing files and documents can be scattered, stacked, spun, etc. The users can interact with objects on like they would do in the real world: a physics engine makes the interaction feel more continues and analogue, e.g. objects can collide and displace others. The approach uses piling instead of filing, which leverages the user's spatial memory. Pen-based interaction metaphors are used to additionally enhance the feeling of realism and directness of manipulation. Figure 2 shows a snapshot of the BumpTop prototype.

Figure 2. BumpTop prototype (Agarawala et al., 2006)

@VISOR (Deller et al., 2006; Dengel et al., 2006) strives to realize the vision of a fully immersive virtual desktop by designing methods to present and visualize data in a way that integrates the user into his artificial surroundings seamlessly and gives him/her the opportunity to interact with it in a natural way. In this connection, a holistic context and content-sensitive approach for information retrieval, visualization, and navigation in manipulative virtual environments is in the research focus.

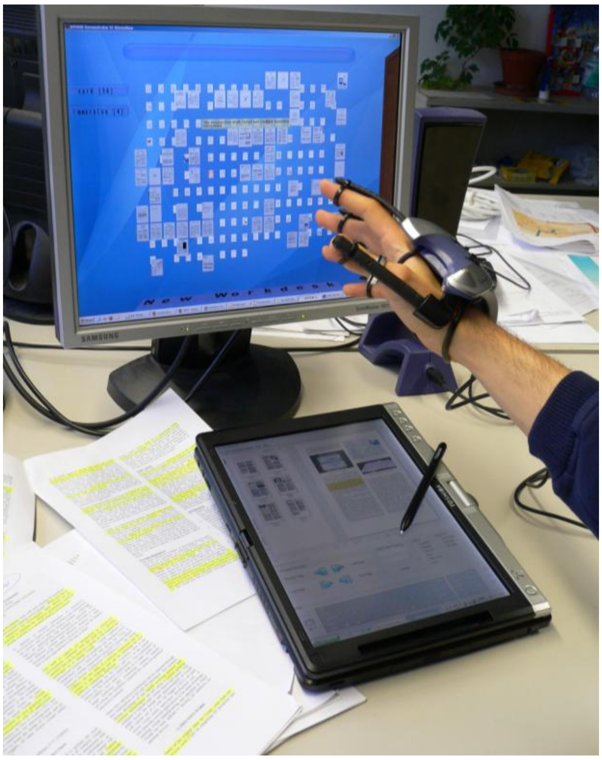

Figure 3. 3Book Dimensional congruence (Baumgärtner et al, 2007)

Like the BumpTop, @VISOR uses a piling instead of the common filing approach. Furthermore, the concept of dimensional congruence to find best-matches for the dimensionality of interaction, task and visualization demands is introduced (Baumgärtner et al, 2007). The resulting system prototype defines a combined 2D + 3D visualization and interaction interface. Interaction is adapted to complement visualization dimensionality in order not to sacrifice task performance. An auto-stereoscopic 3D display and an optically tracked P5 consumer data glove in combination with a pen-based tablet pc as a complementary device are used. The 3D display is used as context and the tablet as focus display. Figure 3 shows a snapshot of the prototype.

The general characteristics of state of the art document environments can be summarized as follows:

- Representation of objects, object states and actions performed on objects intended to optimally support human perception, as well as overcome human limited memory and attention capacities.

- Interaction paradigms that support indicating objects, acting on them directly, and delegating activities on these objects to the system in a more or less “natural” or “intuitive” way.

- Interaction paradigms that support various views on, and navigation through, the object world in a way that matches human interaction with objects and navigation in traditional physical document worlds.

The above-mentioned examples of document information environments certainly do not indicate the end of the development. New display techniques and interaction tools are emerging, allowing multiple users to collaborate (both co-located and at a distance) working with complex document structures in a world that might support group authoring in ways that match natural human collaboration. The analysis in the next section is intended to develop design knowledge to optimally support this.

Fluid annotations (Zellweger, 2000) were introduced to allow awareness of recent interactive behavior while working with documents during reading and browsing, by fluidly adjusting the typography on demand.

There are several web-based tools in use to support collaborative writing. File exchange is the most common activity supported by email or file servers to send files to each other. Google Docs, in addition to document sharing, web-based word processing, and spreadsheet, presentation, and form, and data storage service, offers more advanced facilities like real time co-editing of documents. Tools like Dropbox and Box.net provide cloud-based web hosting and data sharing facilities that support collaborative writing. Adobe Connect and comparable tools support web conferencing including real time desktop sharing.

COLLABORATIVE AUTHORING IN THE DOMAIN OF KNOWLEDGE WORK

Approach

Expert knowledge: scientists (1 woman and 9 man from 4 nationalities: German, Dutch, American and Indian) were interviewed in a one-to-one session during about an hour while they were working. These were contextual interviews at the interviewees’ work place. These scientists were experts in domains like AI, 3D-visualization, Urban Planning, Knowledge management, HCI and Sociology. The questions were intended to collect explicit knowledge: on authoring activities, use of tools, and patterns of collaboration.

At the same time, pictures were taken in the offices, and subsequent questions were asked about objects, and their relation with relevant activities, which allowed the collection of originally implicit knowledge. In a few cases we recorded video clips in activities and the use of objects and tools.

Group knowledge: Explicit group knowledge is often available from documents and artifacts. In our case, the overview of the knowledge collected this way is already presented in previous sections.

As a separate source for implicit group knowledge we used the records of ethnographic studies carried out on 30 academic researchers mainly from the Chemistry and Biology fields (Vyas et al., 2006). “Ethnography by proxy” was performed by asking these scientists to keep a diary for a 10 day period (paper based as well as the online version) where they were asked to list details about their daily activities regarding (co-)authoring. In addition, job-shadowing was performed where researchers were observed during a whole day to understand their work flow and identify everyday activities and interactions regarding work practices related to paper writing. The resulting database allowed us to apply qualitative data analysis software, resulting in patterns of people characteristics and related tasks, goals, tools used and workflow structures. Based on these patterns we developed a set of personas (Cooper, 1999) representing agent types. We decided to characterize these personas with attributes that are relevant for the task domain: professional goals, tasks, professional background, work activities, and tools and resources.

Obviously, many findings in this domain seem trivial, so we will not provide a complete task domain model. For each of the elements of a task model (agents, roles, activities, object and environment, and events) we will only exemplify findings to illustrate the fine grain resulting task knowledge as far as possibly relevant for envisioning future supporting technology. Whenever relevant we will illustrate this by quotes or pictures from our empirical studies.

Resulting Task Model Elements

Agents. Several types of agents are identified, human agents as well as non-human agents. Human agents varied in level of expertise in their scientific domain (with qualifications ranging from full professors to master students). Author teams were another type of agents, and, remarkably, in many cases they consist not only of agents with different levels of expertise, but also of agents from very different disciplines (e.g., both statisticians and biologists).

A specific type of agents can be labeled “**support staff**”. Examples of human support staff are graphic designers, statisticians, and gofers:

> “*NN it is mainly using Visio and Coreldraw for my pictures*”;
>
> “*I make a list and give it to a student, and say copy these*”.

In addition, in this category we find non-human agents, i.e., supporting tools and systems:

> “*I often use Citeseer, Google Scholar or another…*“.

The persona in Figure 4 shows the level of detail that seems relevant for our goal:

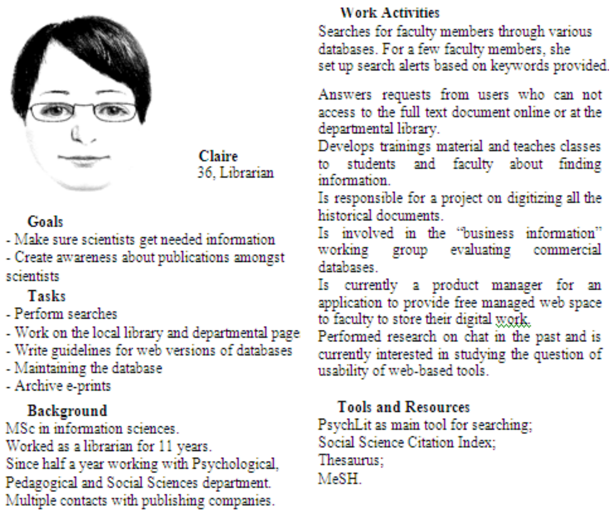

Fig. 4. Persona Librarian.

Roles. Common roles in this task domain are **Author** and **Content Editor**, this last one related to current practice where academic publishing is mostly group work:

> “*I never write a paper alone. I can almost not remember my last paper that I was single author.*”

We found evidence for specialized roles that could, if needed, be delegated or mandated to agents of the type support staff, like **Literature Searcher:**

> “*I prefer journal articles, because they are strictly referenced, and contain a lot of information and because they are a bit more stable work*”;

or **Spelling Editor**. These roles are in some cases given to real specialists:

> “*in some of these papers my contribution is like five percent, which is mainly language checking …. sanity checks and so on.*”

Activities. The process of collaborative authoring includes activities and tasks at several levels.

High level activities are, e.g., having a planning meeting, brainstorming, decision making about the delegation or mandating of subtasks.

Medium level activities are often performed by a single agent, like writing the intro, building statistical graphs from tables, or collecting references:

> *"I am writing it now and this pile is the material that I condensed together. These are my references".*

The category of **low level activities** contains many indications of functionality we might consider to provide in the future through ICT, like combining documents (text fragments, graphs) into a single object; making an object ready to be changed by other agents, or unchangeable for other agents; finding single documents from an ordered or unordered pile:

> "*ones in a while I go through a pile, I know something; I remember! ... And they are systematic piles*",

making notes in relation to the content of a paper:

> *"Post-it's, I had them around my screen (pointing to a large screen)*",

and storing documents electronically:

> *"I want to have it electronically ... to copy-paste the title for reference".*

Objects. Obvious objects in this domain are **documents** (which may contain many other individual documents, like in the case of books or journal issues; or may be relatively atomic, like single text paragraphs, individual pictures, or single literature references). In current practice these can be both physical and electronic, and it is not uncommon that a document is kept and used in both states at the same time, with all problems related to version control and integrity of the "original". Other common types of objects are **Containers** (for physical objects: bookshelf, drawer, pile; for electronic objects: USB device, private and shared directories; each of these with issues on storage and retrieval) and **Combiners** (intended to be permanent: staple, single pdf file; or enabling modification or split: paperclip, directory, MS word file). Most of the objects could be identified by inspecting pictures and videos from the work places (including work with advanced ICT systems like illustrated before), and asking agents about the use of these objects.

In this way we identified a variety of combiners (paper perforator, to enable temporary binding; paper clips; stapler, to allow relatively fixed combinations; paper weight that allows rather easy recombination; and even an unbound pile that was, according to the owner, intended to be easily reshuffled for use during telephone calls.

Events. Events are triggers in the activity context that result in starting, changing, or stopping an activity. Start events for writing a paper were found in a large variety:

> "*my boss said 'I want a paper there*";
> "*start a new project and you know you have to write papers and deliverables*";
> "*you can be invited to write a piece*";
> "*a call for papers pops up and you think now I really should write*".

A **deadline event** changes the mode of collaboration:

> "*first we do this completely anarchy model, and then 'the deadline is in twelve hours!' and then the first author takes the knife*".

A **stop event** in the domain of collaborative authoring often is related to a real "calamity", like a change in job situation of one of the team members.

CONCLUSIONS AND REFLECTIONS

Our task modeling exercise shows that techniques for collecting task knowledge can be tuned to a more detailed level of modeling task world elements. This level of detail is needed for professional collaborative work. Designing for collaborative authoring requires a thorough analysis of possibilities of emerging technology to support the functionality needed.

The functionality considered will range from delegation to a system of roles as we identified them; to providing new varieties of the objects that we found the users in this domain prefer to use (e.g., containers and combiners with the type of attributes our users need); to support for storage and retrieval in complex document structures; to support for keeping track of the state of the situation (i.e., supporting situational awareness); to support for adjusting to (unforeseen) events.

The dialogue paradigms will have to match the type of activity supported and the type of delegation. Combining and splitting objects should be possible as an activity on the objects as such, not requiring the selection of menu options for operations, or the use of magic short cut key combinations.

All interaction with the system should be represented to the user in an intuitive way, i.e., we might consider gesture input and 3-D representation, as well as consider representational metaphors for searching in time and space.

REFERENCES

Agarawala, A. and Balakrishnan, R. (2006) Keepin' it real: pushing the desktop metaphor with physics, piles and the pen, in *SIGCHI conference on Human Factors in computing systems (CHI'06)*: ACM Press: NY

Asimakopoulos, S., Dix, A., Fildes, R. (2011) Using hierarchical task decomposition as a grammar to map actions in context: Application to forecasting systems in supply chain planning. *International Journal of Human-Computer Studies*, 69 (4), 234-250

Baumgärtner, S., Ebert, A., Deller, M., and Agne, S. (2007) 2D Meets 3D. A Human-Centered Interface for Visual Data Exploration. *Proc. of the SIGCHI* *conference on Human factors in computing systems (CHI'07)*, ACM Press 2273-2278.

Card, S., Hong, L., Mackinlay, J., and Chi, E. (2004-a) 3Book: a 3D electronic smart book, In *Proc. of the Working conference on advanced visual interfaces (AVI '04)*, 303-307.

Card, S., Hong, L., Mackinlay, J., and Chi, E. (2004-b) 3Book: a scalable 3D virtual book, In *Proc. of the CHI Extended Abstracts* 2004, 1095-1098.

Card, S. K., Mackinlay, J. D., and Shneiderman, B. (1999) *Readings in Information Visualization: Using Vision to Think*. San Francisco, CA, USA: Morgan Kaufmann Publishers Inc.

Cockburn, A. (2004) Revisiting 2D vs 3D implications on spatial memory. *Proc. of the Fifth conference on Australasian user interface (AUIC '04)*, 25–31.

Cockburn, A. and McKenzie, B. (2002) Evaluating the effectiveness of spatial memory in 2D and 3D physical and virtual environments. *Proc. of the SIGCHI conference on Human factors in computing systems (CHI '02)*, 203-210.

Cooper, A. (1999) *The inmates are running the asylum*. Indianapolis, IN, USA: Macmillan Publishing Co., Inc.

Deller, M., Ebert, A., Bender, B., and Hagen, H. (2006) Flexible Gesture Recognition for Immersive Virtual Environments. *Proc. of the Conference on Information Visualization (IV '06)*, 563-568.

Dengel, A., Agne, S., Klein, B., Ebert, A., and Deller, M. (2006) Human-centered interaction with documents, *Proc. of the 1st ACM international workshop on Human-centered multimedia*, 35-44.

Forte, A., Bruckman, A. (2007) Constructing text: Wiki as a toolkit for (collaborative?) learning. *Proceedings of the 2007 international symposium on Wikis*, 31-42

Hong, L., Card, S. K., and Chen, J. (2006) Turning Pages of 3D Electronic Books. *Proc. of the 3D User Interfaces (3DUI '06)*, 159-165.

Jordan, B. (1996) Ethnographic Workplace Studies and CSCW, in *The Design of Computer Supported Cooperative Work and Groupware Systems., Human Factors in Information Technology Series, 12*, D. Shapiro, M. Tauber, and R. Traunmuller, Eds. North-Holland: Elsevier

Jordan, B. and Henderson, A. (1995) Interaction Analysis: Foundations and Practice, *The Journal of the Learning Sciences*, *4* (1), 39-103.

Julie Rico, J., Stephen Brewster, S. (2010) Usable gestures for mobile interfaces: evaluating social acceptability . *Proceedings of the 28th international conference on Human factors in computing systems*, 887-896

Lawrence, D.A., Pao, L.Y., White, A.C., Xu, W. (2004) Low cost actuator and sensor for high-fidelity haptic interfaces. *Proceedings of the 12th international conference on Haptic interfaces for virtual environment and teleoperator systems*, 74-81

Mandviwalla, M., Clark, III, S.D., Sandoe, K. (1995) Collaborative writing as a process of formalizing group memory. *28th Hawaii International Conference on System Sciences*, 342.

Mistrzyk, T., Redenius, A. (2009) Practical Use of Task Models for Building and Modeling Operations Chart in the Industrial Production. *Proceedings Human-Computer Interaction International* 2009, 140-148

Robertson, G., Czerwinski, M., Larson, K., Robbins, D. C., Thiel, D., and van Dantzich, M. (1998) Data mountain: using spatial memory for document management. *Proc. of the 11th annual ACM symposium on User interface software and technology*, 153-162.

Sebillotte, S. (1988) Hierarchical planning as a method for task-analysis: the example of office task analysis, *Behaviour and Information Technology*, *7*(3), 275-293.

Sellen, A. J. and Harper, R. H. R. (2003) *The Myth of the Paperless Office*: MIT Press.

Spence, R. (2007) *Information Visualization*. New York: ACM Press.

van der Veer, G. C. and del Puerta Melguizo, M. C. (2003) Mental models, in *Human-Computer Interaction Handbook: Fundamentals, Evolving Technologies and Emerging Applications*, J. A. Jacko and A. Sears, Eds. Mahwah, NJ: Lawrence Erlbaum Associates, 52-80.

Van Welie, M. and van der Veer, G. C. (2003) Groupware Task Analysis, in Hollnagel E. (Ed.) *Handbook of Cognitive Task Design*, New Jersey, US: Lawrence Erlbaum Associates Inc., 447-476.

Vyas, D., de Groot, S., and van der Veer, G. C. (2006) Understanding the Academic Environments: Developing Personas from Field-Studies., In *Proc. of the 13th European Conf. on Cognitive Ergonomics*, ACM Press: NY, 119-120.

Ware, C. (2000) *Information Visualization: Perception for Design*. San Francisco, CA, USA: Morgan Kaufman Publishers.

Zellweger, P.T., Harkness Regli, S., Mackinlay, J.D., and Chang, B.-W. (2000) The impact of fluid documents on reading and browsing: an observational study. *CHI'2000*. The Hague: ACM Press, 249-256.